

## Are honey bees (*apis mellifera* L.) native to the British Isles?

Article (Unspecified)

Carreck, Norman (2008) Are honey bees (*apis mellifera* L.) native to the British Isles? *Journal of Apicultural Research*, 47 (4). pp. 318-322. ISSN 0021-8839

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/43702/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

### **Copyright and reuse:**

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

## REVIEW ARTICLE



# Are honey bees (*Apis mellifera* L.) native to the British Isles?

**Norman L. Carreck<sup>1</sup>\***

<sup>1</sup>New Hall, Small Dole, Henfield, West Sussex, BN5 9YJ, UK.

\*Corresponding author. Email: [norman.carreck@btinternet.com](mailto:norman.carreck@btinternet.com)

## Summary

Biological, historical and archaeological evidence proves that honey bees (*Apis mellifera* L.) have been present in the British Isles for at least 4000 years, and suggests that they probably entered from southern Europe after the retreat of the last Ice Age. Recent studies show that rather than having been destroyed by disease in the early 20th century, or obliterated by imports of other strains of honey bee, the dark European honey bee *Apis mellifera mellifera* still exists as genetically distinct populations in various parts of Britain. There is little information available to indicate the extent of any competition between honey bees and other species of bee in Britain, or to quantify the contribution of honey bees to major ecosystems in Britain. There is a need for strategies for conserving rare or endangered bee species to recognise that local strains of honey bee may be equally endangered, and may be equally deserving of conservation effort. All species of bee are worthy of conservation, and management decisions need to be made on a case by case basis, and must be based on a sound understanding of the underlying biology of the ecosystems involved.

## Son las abejas nativas de las Islas Británicas?

### Resumen

Las pruebas biológicas, históricas y arqueológicas demuestran que las abejas (*Apis mellifera* L.) han estado presentes en las Islas Británicas desde hace al menos 4000 años, y sugieren que se introdujeron probablemente desde el sur de Europa después de la última glaciación. Estudios recientes muestran que, tras las pérdidas de abejas debidas a enfermedades durante el siglo XX o las introducciones de otras razas de abejas, la abeja negra europea (*Apis mellifera mellifera*) aún existe como poblaciones genéticamente distinguibles en varias partes de Gran Bretaña. Hay poca información disponible para indicar el grado de competencia entre la abeja de la miel y otras especies de abejas en Gran Bretaña, o para cuantificar la contribución de la abeja de miel en los principales ecosistemas de Gran Bretaña. Existe una necesidad de estrategias de conservación para especies de abejas raras o en peligro de extinción, para reconocer qué variedades de la abeja de la miel se encuentran en peligro de extinción y pueden ser dignas de esfuerzos conservacionistas. Todas las especies de abejas son dignas de conservación, y las decisiones de gestión deben ser realizadas caso por caso, y deben basarse en una sólida comprensión de la biología subyacente de los ecosistemas involucrados.

**Keywords:** *Apis mellifera mellifera*, dark European honey bee, British Isles, bee conservation.

## Introduction

To honey bee scientists and beekeepers, the title might seem a curious question to ask. Books discussing the history of beekeeping or honey bee races (e.g. Crane, 1983; Cooper, 1986; Ruttner, 1988; Crane, 1999) include the British Isles within the natural range of *Apis mellifera* (specifically *A. m. mellifera*, the dark European honey bee) without question. In the UK, however, some professional conservationists have recently come to regard the honey bee as an alien creature, and have even gone so far as to

suggest that it should be excluded from nature reserves (Randall and Sheppard, 2007). A review of the native status of the honey bee in the British Isles is therefore long overdue.

### Biological evidence

As recently as 2003, a review concerning competition between honey bees and other species of bee (Goulson, 2003) quoted a statement taken from Michener (1974) to the effect that: "The honey bee is thought to be native to Africa, western Asia, and south east Europe", adding that "its association with man is so ancient that it is hard to be certain of its origins", presumably

implying that it had been introduced to western Europe and Britain by man. Michener has, however, recently (pers. comm., 2008) clarified his statement by saying: "I did not intend to indicate that I thought the arrival of honey bees in Britain was modern. The land connection of Britain and Europe only a few thousand years ago presumably indicates that Britain is best regarded as part of the continent for this purpose".

In 1978, Ruttner *et al.* concluded from morphometric studies that the western European races of honey bee (*Apis mellifera mellifera* and *A. m. iberica*) were not very closely related to the eastern and southern European races (*A. m. ligustica*, *carnica*, *cecropia*). They suggested that the western and northern European races (which they designated group "M") had entered Europe from Africa (the bees of which they designated group "A") via the Iberian peninsula, whilst the eastern European strains (which they designated group "C") entered via the Near East, the physical barrier between the two groups having been the Alps.

As part of the Honey Bee Genome Project (Honey Bee Genome Sequencing Consortium, 2006), molecular techniques were used to examine various strains of honey bee, and the results confirmed this lack of a close relationship between the western and north European (M) and eastern European (C) groups, and furthermore proposed a fourth group, designated "O", and comprising the near eastern races *A. m. anatolia*, *caucasica* and *syriaca*, as being intermediate between the groups A and C. It was therefore suggested that the origin of evolution of *Apis mellifera* lies in Africa, rather than in Asia, as previously thought (Witfield *et al.*, 2006). This confirms the antiquity of honey bees in western and northern Europe.

### Written evidence

The first English book on beekeeping was probably Southerne's *Treatise*, published in 1593, and the first printed illustration of bees and hives, that in *The grete herball*, published in 1526 (Harding *et al.*, 1979). Many references to bees and beekeeping pre-date the introduction of printing to Britain (Fraser, 1958). The Norman conquest in 1066 AD is generally regarded as the beginning of the Mediaeval period, but it must be realised that Domesday Book of 1086 AD (Morris, 1972-1986) which makes a definitive record of the *status quo* at that time is therefore record of the pre-mediaeval period. It contains numerous references to bees and beekeeping (Fraser, 1958).

Before the Norman conquest, *Rectitudes singularum personarum* (c. 1000 AD) outlines the rights and duties of a beekeeper (Fraser, 1958), whilst the Anglo-Saxon Laws, comprising those of King Edward the Confessor (c. 1050 AD), King Alfred (c. 890 AD) and King Ina (c. 700 AD), mention punishments to be meted out to thieves who stole from beekeepers (Fraser, 1958). The Ancient Laws of Wales, codified by Howell the Good in 918 AD are based on much older material, and record the established customs observed by various tribes. They include records of mead making, and record the monetary value of bee swarms (Fraser, 1958). The *Bechbretha* or Ancient Bee Laws of Ireland, said to have been codified by St. Patrick in 438 – 441 AD, were more probably first written down in the 7th century, but importantly are not laws as such, but legal judgements passed down in the oral tradition and which clearly date back many centuries (Ryan, 2005). The judgements indicate that there were wild colonies of honey bees in woodland, and

also hives managed by beekeepers. It must be borne in mind that the Romans never occupied Ireland, and thus could have had no direct influence on any beekeeping traditions there.

Although it has been claimed that the Romans brought bees to Britain, there appears to be no documentary evidence for this. The only written reference to beekeeping or honey in Roman Britain seems to be a reference (c. 100 AD) to *lini mellari*, a beekeeping cloth of some kind, perhaps used to cover a hive or to strain honey, included in an inventory of items at Vindolanda, Northumberland (Crane, 1999). Finally, we must not forget the Greek explorer Pytheas of Marseilles (c. 300 BC) who wrote that the inhabitants of Thule prepared a drink of grain and honey (Fraser, 1958). Thule has been variously placed by later historians as north of Great Britain, possibly the Orkneys or Shetland Islands.

### Archaeological evidence

Until the introduction of wooden bee hives in the 19th century, the hives traditionally used in Britain were made from wicker or straw, and are thus, in common with the bees that lived in them, under normal conditions unlikely to survive in archaeological deposits. The earliest structures to survive therefore are not hives, but bee boles and bee houses, built of stone or brick. These are often difficult to date, but the earliest surviving seem to date from the 15th century (Crane, 1983; Foster, 1988; Ogden, 2001).

In the last few decades, however, excavations at sites including waterlogged levels, where organic material survives, have greatly increased our knowledge. The extensive excavations at Coppergate, York between 1976 and 1981 of an Anglo-Scandinavian (Viking) settlement (Kenward and Hall, 1995) revealed many traces of bees and bee products, suggesting, but not proving, that bees were kept in this urban situation. It has even been suggested that puff-ball fungi (*Langermannia gigantea*) found nearby could have been burnt to subdue bees using the smoke produced (Kenward and Hall, 1995), as recommended by the Rev. John Thorley some 800 years later (Brown, 1994). Wings of honey bees from levels dated to c. 935-975 AD have been identified by morphometry to be *A. m. mellifera* (Ruttner *et al.*, 1990).

Nothing in the way of honey bee related material seems to survive from the Anglo-Saxon period, and until recently, the only evidence of honey bees in Roman Britain was a small glass vessel containing honey from Bartlow Hills, Cambridgeshire (Ward, 1911). The recent extensive excavations between 1998 and 2006 at Perry Oaks, Middlesex, on the site of the new Terminal 5 at Heathrow Airport, have, however, revealed new information. A mid-Roman waterhole contained 16 honey bees in a small sample of material (Robinson, 2007). The presence of so many bees in one place, close to known dwellings in an open agricultural landscape, strongly suggests beekeeping.

Of the period before the Roman conquest of Britain, remains from the Iron Age currently seem to be confined to the head of a single worker honey bee from Iron Age (c. 220 BC) peat deposits at Mingies ditch, Oxfordshire (Robinson, 1984; Allen and Robinson, 1993). More evidence seems, however, to be emerging from the earlier Bronze Age. A beaker and associated plant material from a Bronze Age burial cist at Ashgrove in Fife, Scotland, dated to c. 1000 BC, contained pollen grains of small leaved lime (*Tilia cordata*) and meadowsweet (*Filipendula ulmaria*), suggesting that it contained either mead or honey (Dickson, 1978; Dickson and Dickson, 2000).

The presence of lime trees in this location at this date is, however, uncertain (Tansley, 1965; Rackham, 2003), so this mead or honey may have come from elsewhere. In 1992, a Bronze Age boat, dated to c. 1550 BC was excavated at Dover Kent. This was in excellent condition, revealing that it had been made reasonably watertight using a caulking of moss and beeswax (Clark, 2004). Being a boat thought capable of crossing the English Channel, it may of course not have been constructed in Britain but on the coast of mainland Europe.

More definite evidence for honey bees in Britain at this time has come from Runnymede, Berkshire, where a single worker bee was found in late Bronze Age deposits (Robinson, 2000), and recently from the Perry Oaks excavations, Hayes, Middlesex, where parts of two honey bee workers were found in two separate middle Bronze Age (c. 2000–1700 BC) pits (Robinson, 2007). These three finds represent the earliest examples of honey bees yet known in Britain. Indirect earlier evidence does, however, also exist. Burnt organic remains on pot sherds from Neolithic (c. 3000–2650 BC) deposits at Runnymede Bridge, Berkshire have been analysed and found to contain traces of beeswax (Needham and Evans, 1987). This may have been used to waterproof the pottery, or may represent cooking remains.

None of these finds exclude the possibility that honey bees may have been brought to Britain by man in the Neolithic or Bronze Age, but these latest discoveries take honey bees back relatively close to the period when a land bridge with mainland Europe existed until c. 5000 BC. Furthermore, whilst proving the presence of honey bees and honey bee products in Britain, there appears to be no conclusive evidence that bees were managed in hives by man in Britain until around the time of the Roman conquest. It seems much more likely that in the Neolithic and Bronze Age, bees were exploited as part of a "forest beekeeping" system (Crane, 1999) or merely by "honey hunters" (Ogden, 2001). It is extremely unlikely that before the advent of some kind of bee hive, man would have possessed the technology to move colonies of honey bees from one place to another.

The pollen record suggests that Britain had a flora including plants suitable for bee forage by 7500–5000 BC, and more specifically, Limbrey (1982) convincingly argued that colonisation of Britain by honey bees may have occurred at the same time as that of lime (*Tilia* sp.) and hazel (*Corylus avellana*) trees, dated at Hockham Mere, Norfolk to 6250 BC.

Finally, we should not overlook the fact that during the last (Ipswichian) interglacial period (c. 120,000 BC) the climate of what is now Britain was significantly warmer than today, supporting present day British flora such as oak (*Quercus* spp.) and hazel, but also southern insect-pollinated species such as the Montpellier maple (*Acer monspessulanum*) and the water chestnut (*Trapa natans*), which can now no longer grow in Britain (Sutcliffe, 1985). Coope (2000) and Gao *et al.* (2000) examined insect assemblages from Ipswichian and possibly earlier deposits and found Coleoptera including dung and bark beetles, some of which are found in Britain today, but others are now found at southern latitudes including the Mediterranean, India and north Africa. Were honey bees also present in Britain at that time?

### Survival of *Apis mellifera mellifera* in Britain today

Taken together, the biological, written and archaeological records thus prove beyond all reasonable doubt that the honey bee was

present in Britain several millennia before either the Roman or Norman invasions. It seems most likely that it has been present since such time after the retreat of the last Ice Age as conditions allowed colonisation by forage plants suitable for both it and the 250 or so other species of bee native to Britain.

A crucial question arises, however, as to whether the native *A. m. mellifera* still survives today. Many authorities have considered that it was entirely eliminated from Britain by the ravages of the "Isle of Wight disease" in the early 20th century, at that time thought to have been caused by the tracheal mite *Acarapis woodi* ("acarine disease"). In particular, Adam (1983) categorically stated that: "The old English brown bee... lives today only in the memory. Some 50 years ago she fell a victim to the acarine epidemic and was completely wiped out". Recent re-evaluation of the "Isle of Wight disease" (Bailey and Ball, 1991; Bailey, 2002) has suggested both that the underlying cause was unlikely to have been *A. woodi*, and that contemporary accounts greatly exaggerated the extent of losses of colonies. What is certain, however, is that very considerable imports of honey bees to Britain from mainland Europe, mainly, but not exclusively, of *A. m. ligustica*, took place from 1859 onwards, and greatly increased in attempts to re-stock after the "Isle of Wight disease". The majority of managed colonies, particularly in south-eastern England, consequently today consist of various hybrids of *A. m. mellifera*, *A. m. ligustica* and other sub-species.

Dissatisfaction with some of these hybrids in the period after the Second World War led some British beekeepers to re-evaluate *A. m. mellifera*, and wonder whether it still survived in Britain. It was rapidly found that pockets of dark coloured bees existed in many parts of Great Britain and Ireland, and morphometric studies, especially of wing venation, and comparison with pre-1850 museum specimens, showed that they were indeed *A. m. mellifera* (Cooper, 1986; Ruttner *et al.*, 1990). Recent mitochondrial DNA studies undertaken as part of the EU funded project: Beekeeping and Apis Biodiversity in Europe (Jensen and Pederson, 2005) have confirmed that genetically distinct British populations of *A. m. mellifera*, related to other populations from Denmark, Finland, France, Norway and Sweden, still exist at several locations in England, Ireland and Scotland, together with another population in Tasmania, Australia, known to have been imported from England in 1831 (Weatherhead, 2007).

### Implications for bee conservation

It seems self-evident that if honey bees are introduced to areas where they are not native, they may compete with the local bee fauna for floral and other resources. Many studies of inter-specific bee competition have been carried out, mainly in Australasia and the Americas, and there have been several recent reviews. Probably due to the inherent difficulties in carrying out such studies, the results have, however, generally been inconsistent. Butz Huryn (1997) concluded that: "experiments have not shown competition for nesting sites between honey bees and native fauna. The presence of honey bees, however, alters the foraging behaviour and abundance of some native fauna on flowers, but no studies have shown detrimental impacts of honey bees on population abundances of any native animals or plants. Anecdotal and quantitative reports of increased honey bee abundances on flowers compared with native fauna are often confounded with habitat changes induced by man". Goulson (2003) concluded that:

"Research to date has focussed mainly on *A. mellifera* and has largely been concerned with detecting competition with native flower visitors. Considerable circumstantial evidence has accrued that competition does occur, but no experiment has clearly demonstrated long term reductions in populations of native organisms. Most researchers agree that this probably reflects the difficulty of carrying out convincing studies of such mobile organisms, rather than a genuine absence of competitive effects".

In Europe, where the honey bee is native, the situation is even less clear, and few studies have been carried out. Steffan-Dewinter and Tschamntke (2000) studied the interactions between honey bees and solitary and bumble bees on grassland in Germany and found no significant competition effects. Walther-Hellwig *et al.* (2006) studied the effect of introducing honey bee colonies into an agricultural landscape on the density of bumble bees. They found little effect on short tongued bumble bees such as *Bombus terrestris*, but observed a shift between plant species in longer tongued bees such as *B. pascuorum*. In seemingly the only significant study carried out in Britain, Forup and Memmott (2005) sampled bee abundance on lowland heaths in southern England and concluded that: "the impact of honey bees on bumble bees is complex. Although competition between the two species cannot be ruled out, it is perhaps equally likely that bumble bees decline in response to other factors, and that honey bees move independently of this decline".

The present agricultural landscape of Britain is very different from that which existed before the Neolithic period. Honey bees are woodland creatures, nesting in cavities such as hollow trees. Rackham (1986) has pointed out that whilst the prehistoric "wildwood" would have contained many ancient trees, traditional woodland managed in the historical period for timber and wood production contained few trees of any great age, since ancient rotten and hollow trees had no monetary value. We cannot know at what density honey bee colonies existed in prehistoric woodland, but in terms of nest sites, the agricultural landscape that replaced it was far less accommodating. Wildwood would have included abundant flowering trees and shrubs, but arable land replacing it traditionally contained many flowering weeds, and similarly, traditionally managed grassland contained many forb species yielding nectar and pollen. Due to their generalist nature and ubiquity, it seems inconceivable that honey bees did not play an important part in the evolution of major ecosystems during man's "traditional" agriculture over the last few millennia and up until the Second World War.

Honey bee populations in Britain have undoubtedly declined during the 20th century. Bailey (2002) estimated that there may have been a million managed colonies of honey bees in England and Wales in 1910. As well as the outbreaks of the "Isle of Wight disease" already mentioned, major losses subsequently occurred due to American and European foulbrood, which only came under statutory control in 1942 (Bailey and Ball, 1991). Since its discovery in Britain in 1992, the parasitic mite *Varroa destructor* has also seriously reduced colony numbers, in particular by destroying wild colonies living in trees and other places. As well as disease, the popularity of beekeeping has been affected by social and economic factors. After a boom period at the time of the Second World War when sugar was rationed, the number of beekeepers entered a long period of decline, from which it only now shows some signs of recovery, due perhaps to increased interest in conservation. Changes in land use since the Second World War have seriously reduced the availability of bee forage plants, and hence the viability of beekeeping

(Williams and Carreck, 1994; Carreck and Williams, 1998). In 2006 there were estimated to be 250,000 managed honey bee colonies in England and Wales (Cuthbertson and Brown, 2006), a reduction of 75% over the last century.

The pollination requirements of most cultivated crops have been extensively studied (Free, 1993; Delaplane and Mayer, 2000), but those of most of the nearly 1800 species of wild plants in Britain are entirely unknown (Corbet *et al.*, 1991). We are thus almost wholly ignorant of the role that honey bees play in major ecosystems in Britain, although, as argued above, it could be important. There is thus an urgent need for research into the entire pollinator community in these ecosystems. It is clear that it would be extremely unwise to introduce 200 colonies of honey bees into a sensitive area known to have rare or threatened bees or plants. It seems, however, equally unwise to arbitrarily remove honey bees from another area where they have always existed, perhaps in the past in greater numbers, without any real understanding of the possible consequences of this action. Nature reserves rarely represent "wildwood" or other wilderness. They generally represent "traditional" farmland whether it be hay meadows, water meadows, coppiced woodland or heathland, all of which have been artificially created by human management, and honey bees have been present throughout that period of human intervention.

The attitude of some professional conservationists towards honey bees seems to stem from the belief that honey bees are "domesticated", and should therefore be considered no different from domestic sheep, cattle or ponies (Randall and Sheppard, 2007). Although honey bees have indeed long been managed by man (Crane, 1999), they differ from other domestic livestock in one crucial respect. They cannot live for long in confinement. Although it is possible to keep small honey bee colonies in indoor flight rooms for some months (Poppy and Williams, 1999), queens cannot mate under such conditions. Instrumental Insemination remains a specialist procedure, so it is extremely difficult for the ordinary beekeeper to control mating, and it is thus difficult to selectively breed honey bees. For example, despite considerable expenditure in time and money over many years, selective breeding for resistance to *V. destructor* has been painfully slow (Carreck, 1998). Mating in the vast majority of honey bee colonies in Britain is entirely uncontrolled. For this reason, the distinctiveness of the remaining populations of pure *A. m. mellifera* could easily be threatened by the thoughtless introduction of other strains of honey bee nearby (Jensen *et al.*, 2005). There is thus a need for strategies for conserving rare or endangered bee species to recognise that local strains of honey bee may be equally endangered, and may be equally deserving of conservation effort. It must be recognised that all species of bee are worthy of conservation, that management decisions need to be made on a case by case basis, and that they must be based on a sound understanding of the underlying biology of the ecosystems involved.

## Acknowledgements

I would like to thank the following for information, helpful discussions or comments on an earlier draft of this manuscript: Andrew Abrahams (Colonsay, Scotland); John Dews (Bee Improvement and Bee Breeders Association); Robert Field (Bee Farmers Association of the UK); Prof. Dave Goulson (University



of Stirling); Harry Kenward (University of York); Prof. Charles Michener (University of Kansas); Dr Bo Vest Pederson (University of Copenhagen); Dr Dorian Pritchard (Societas Internationalis pro Conservatione Apis Melliferae Melliferae); Jim Ryan (Editor, *An Beachaire*); Trevor Weatherhead (Weather-Bee Apiaries, Australia); Dr Paul Williams (Natural History Museum, London).

## References

- ADAM, BROTHER (1983) *In search of the best strains of bees*. Northern Bee Books; Hebden Bridge, UK. 206 pp.
- ALLEN, T G; ROBINSON, M A (1993) *The prehistoric landscape and Iron Age enclosed settlement at Mingies Ditch, Hardwick-with-Yelford, Oxon*. Oxford University Committee for Archaeology; Oxford, UK. 249 pp.
- BAILEY, L (2002) *The Isle of Wight disease*. Central Association of Bee-Keepers; Poole, UK. 11 pp.
- BAILEY, L; BALL, B V (1991) *Honey Bee pathology*. Academic Press; London, UK. 193 pp.
- BROWN, R (1994) *Great masters of beekeeping*. Bee Books New and Old; Charleston, UK. 120 pp.
- BUTZ HURYN, V M (1997) Ecological impacts of introduced honey bees. *Quarterly Review of Biology* 72: 275–297.
- CARRECK, N L (1998) Tolerance of honey bees to *Varroa jacobsoni* – a review. *Beekeepers Quarterly* 54: 24–27.
- CARRECK, N L; WILLIAMS, I H (1998) The economic value of bees in the UK. *Bee World* 79: 115–123.
- CLARK, P (Ed.) (2004) *The Dover Bronze Age boat*. English Heritage; London, UK. 464 pp.
- COOPE, G R (2001) Biostratigraphic distinction of interglacial coleopteran assemblages from southern Britain attributed to Oxygen Isotope Stages 5e and 7. *Quaternary Science Reviews* 20: 1717–1722.
- COOPER, B A (1986) *The honey bees of the British Isles*. British Isles Bee Breeders Association; Derby, UK. 158 pp.
- CORBET, S A; WILLIAMS, I H; OSBORNE, J L (1991) Bees and the pollination of crops and wild flowers in the European Community. *Bee World* 72: 47–59.
- CRANE, E (1983) *The archaeology of beekeeping*. Duckworth; London, UK. 360 pp.
- CRANE, E (1999) *The world history of beekeeping and honey hunting*. Duckworth; London UK. 682 pp.
- CUTHBERTSON, A G S; BROWN, M A (2006) The value of the honey bee and the need for it to be protected. *Biodiversity News* 35: 14–15.
- DELAPLANE, K S; MAYER, D F (2000) *Crop pollination by bees*. CABI Publishing; Wallingford, UK. 344 pp.
- DICKSON, J H (1978) Bronze age mead. *Antiquity* 52: 108–113.
- DICKSON, C; DICKSON, J H (2000) *Plants and people in ancient Scotland*. Tempus Publishing. 320 pp.
- FORUP, M L; MEMMOTT, J (2005) The relationship between the abundances of bumble bees and honey bees in a native habitat. *Ecological Entomology* 30: 47–57.
- FOSTER, A M (1988) *Bee boles and bee houses*. Shire Publications; Aylesbury, UK. 32 pp.
- FRASER, H M (1958) *History of beekeeping in Britain*. International Bee Research Association; London, UK. 106 pp.
- FREE, J B (1993) *Insect pollination of crops (2nd Ed.)*. Academic Press; London, UK. 544 pp.
- GAO, C; KEEN, D H; BOREHAM, S; COOPE, G R; PETTIT, M E; STUART, A J; GIBBARD, P L (2000). Last Interglacial and Devensian deposits of the River Great Ouse at Woolpack Farm, Fenstanton, Cambridgeshire, UK. *Quaternary Science Reviews* 19: 787–810.
- GOULSON, D (2003) Effects of introduced bees on native ecosystems. *Annual Review of Ecology, Evolution and Systematics* 34: 1–26.
- HARDING, J P; SMITH, D A; CRANE, E; DURUZ, R M (1979) *British bee books - a bibliography 1500–1976*. International Bee Research Association; London. 270 pp.
- HONEY BEE GENOME SEQUENCING CONSORTIUM (2006) Insights into social insects from the genome of the honey bee *Apis mellifera*. *Nature* 443: 931–949.
- JENSEN, A B; PALMER, K A; BOOMSMA, J J; PEDERSEN, B V (2005) Varying degrees of *Apis mellifera ligustica* introgression in protected populations of the black honey bee, *Apis mellifera mellifera*, in northwest Europe. *Molecular Ecology* 14: 93–106.
- JENSEN, A B; PEDERSON, B V (2005) Honey bee conservation; a case study from Læsø Island (DK). In Lodesani, M; Costa, C (Eds) *Beekeeping and conserving biodiversity of honey bees* Northern Bee Books; Hebden Bridge, UK. 142–164.
- KENWARD, H K; HALL, A R (1995) Biological evidence from Anglo-Scandinavian deposits at 16–22 Coppergate. *The Archaeology of York* 14/7: 435–797. York Archaeological Trust / Council for British Archaeology; York, UK.
- LIMBREY, S (1982) The honey bee and woodland sources. In Bell, M; Limbrey, S (Eds) *Archaeological aspects of woodland ecology* Oxford: British Archaeological Reports International Series 146: 279–286
- MICHENER, C D (1974) *The social behaviour of the bees: a comparative study*. Harvard University Press; Cambridge, MA, USA. 404 pp.
- MORRIS, J (Ed.) (1972–1986) *Domesday Book* (34 Vols). Phillimore; Chichester; UK.
- NEEDHAM, S; EVANS, J (1987) Honey and dripping: Neolithic food residues from Runnymede Bridge. *Oxford Journal of Archaeology* 6 (1): 21–28.
- OGDEN, R B (2001) *In pursuit of liquid gold*. Bee Books New and Old; Charlestown, UK. 104 pp.
- POPPY, G M; WILLIAMS, I H (1999) A bee-flight room designed for studies of bee foraging behaviour. *Journal of Apicultural Research* 38: 177–189.
- RACKHAM, O (1986) *The history of the countryside*. Dent; London, UK. 445 pp.
- RACKHAM, O (2003) *Ancient woodland: its history, vegetation and uses in England*. Castlepoint Press; Dalbeattie, UK. 585 pp.
- RANDALL, R; SHEPPARD, D (2007) To bee or not to bee? Honey bees on nature reserves. *Conservation Land Management, Summer 2007*: 16–17.
- ROBINSON, M A (1984) An apicultural postscript: the honey bee in the Iron Age. In Cunliffe, B W; Miles, D (Eds) *Aspects of the Iron Age in Central Southern England*. Oxford University Committee for Archaeology Monograph 2; Oxford, UK. 1–11.
- ROBINSON, M A (2000) Middle Mesolithic to late bronze age insect assemblages and an early Neolithic assemblage of waterlogged macroscopic plant remains. In S. Needham. *The passage of the Thames, Holocene and environment and settlement at Runnymede*. British Museum; London, UK. 146–167.
- ROBINSON, M A (2007) *Analysis of insects from middle Bronze Age to Roman deposits from Perry Oaks*. <http://www.scribd.com/doc/388452/Analysis-of-insects-from-Middle-Bronze-Age-to-Roman-deposits-from-Perry-Oaks>
- RUTTNER, F (1988) *Breeding techniques and selection for breeding of the honey bee*. British Isles Bee Breeders Association; Derby, UK. 152 pp.
- RUTTNER, F; MILNER, E; DEWS, J E (1990) *The Dark European Honey Bee, Apis mellifera mellifera Linnaeus 1758*. British Isles Bee Breeders Association; Derby, UK.
- RUTTNER, F; TASSENCOURT, L; LOUVEAUX, J (1978) Biometrical-statistical analysis of geographic variability of *Apis mellifera* L. I. materials and methods. *Apidologie* 9: 363–381.
- RYAN, J (2005) *Bechbretha*: The ancient Irish bee judgments. In *Proceedings of XXXIXth International Apicultural Congress*, Dublin, Ireland, 21st–26th August 2005. 67.
- STEFFAN-DEWINTER, I; TSCHARNTKE, T (2000) Resource overlap and possible competition between honey bees and wild bees in central Europe. *Oecologia* 122: 288–296.
- SUTCLIFFE, A J (1985) *On the track of Ice Age mammals*. British Museum (Natural History); London, UK. 224 pp.
- TANSLEY, A G (1965) *The British Islands and their vegetation*. Cambridge University Press; UK.
- WALTHER-HELLWIG, K; FOKUL, G; FRANKL, G; BÜCHLER, R; EKSCHMITT, K; WOLTERS, V (2006) Increased density of honey bee colonies affects foraging bumble bees. *Apidologie* 37: 517–532.
- WARD, J (1911) *The Roman era in Britain*. Antiquary's Books; London, UK.
- WEATHERHEAD, T (2007) A history of the introduction of the races of honey bee (*Apis mellifera* Linnaeus) to Australia. *Proceedings of XLth International Apicultural Congress, Melbourne, Australia*, 9th–14th September 2007. 105
- WILLIAMS, I H; CARRECK, N L (1994) Land use changes and honey forage plants. In A. Matheson (Ed.) *Forage for bees in an agricultural Landscape*. International Bee Research Association, Cardiff, pp 7–20.
- WHITFIELD, C J; BEHURA, S K; BERLOCHER, S H; CLARK, A G; JOHNSTON, J S; SHEPPARD, W S; SMITH, D R; SUAREZ, A V; WEAVER, D; TSUTSUI, N D (2006) Thrice out of Africa: ancient and recent expansions of the honey bee, *Apis mellifera*. *Science* 314: 642–645.